

CLAIMS

1. A process for oxidizing organic compounds comprising:
 contacting, in a zone of reaction, an oxidizable organic compound with a peroxide selected from the group consisting of hydrogen peroxide and organic hydroperoxides, in the presence of a catalytically effective amount of an insoluble catalyst comprising silicon oxide and an oxide of at least one peroxide-activating metal prepared by sol-gel techniques, wherein said catalyst is characterized by
 5 (i) the silicon to peroxide-activating atomic ratio is less than 10,000 to 1; (ii) is x-ray amorphous; (iii) possesses a Si-C infrared band; and (iv) has a surface area greater than 500 m²/g, a pore volume greater than 0.5 mL/g and an average pore diameter of greater than 4 nm.
2. The process of Claim 1 wherein the organic compound is selected from the group consisting of:
- (a) cyclic olefins and olefins according to the formula
- 15 $R^1R^2C=CR^3R^4$,
 wherein R^1 , R^2 , R^3 and R^4 are each independently -H; alkyl, wherein the alkyl group has from 1 to 16 carbon atoms; alkylaryl, wherein the alkylaryl group has from 7 to 16 carbon atoms; cycloalkyl, wherein the cycloalkyl group has from 6 to 10 carbon atoms; or alkylcycloalkyl, wherein the
 20 alkylcycloalkyl group has from 7 to 16 carbon atoms; and wherein said olefin can optionally containing halogen atoms;
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- (b) cyclic ketones according to the formula
 wherein n is an integer from 2 to 9;
- (c) compounds of the formula $C_6H_5R^5$, wherein R^5 is -H, -OH; C_1
 25 to C_3 straight chain, saturated or unsaturated hydrocarbon radicals, $-CO_2H$; $-CN$; $-COC_m$, wherein m is an integer from 1 to 6; $-OC_m$, wherein m is an integer from 1 to 6; or NR^6R^7 , where R^6 and R^7 are each independently -H or C_1 to C_3 alkyl groups;
- (d) alicyclic hydrocarbons according to the formula $R^8R^9CH_2$,
 30 wherein R^8 and R^9 together from a link of $(-CH_2-)_p$,
 wherein p is an integer from 4 to 11;
- (e) aliphatic hydrocarbons of the formula C_qH_{2q+2} , wherein q is an integer from 1 to 20; and
- (f) alcohols according to the formula $R^{10}R^{11}CHOH$, wherein R^{10}
 35 and R^{11} are each independently -H; alkyl, wherein the alkyl group has from 1 to 16 carbon atoms; alkylaryl, wherein the alkylaryl group has from 7 to 16 carbon

atoms; cycloalkyl, wherein the cycloalkyl group has from 6 to 10 carbon atoms; cycloalkyl wherein R¹⁰ and R¹¹ taken together form a link containing 4 to 11 -CH₂- groups; or alkylcycloalkyl, wherein the alkylcycloalkyl group has from 7 to 16 carbon atoms.

5 3. The process of Claim 1 wherein the peroxide-activating metal is selected from the group consisting of silver, cobalt, cerium, manganese, iron, copper, molybdenum, tungsten, vanadium, titanium, chromium and mixtures thereof.

10 4. The process of Claim 3 wherein the peroxide-activating metal is tetrahedrally coordinated titanium.

5 5. The process of Claim 1 wherein the catalyst is an amorphous titania/silica aerogel wherein the weight ratio of TiO₂ to SiO₂ is between 0.0005:1 and 0.5:1.

15 6. A process for the preparation of an aerogel catalyst comprising oxides of silicon and a peroxide-activating metal comprising:

- (i) preparing a sol-gel containing silicon and a peroxide-activating metal;
- (ii) extracting the gel with a solvent to remove substantially all of the water from the gel and optionally removing the solvent;
- 20 (iii) washing the gel with a solvent for the silylating agent;
- (iv) treating the gel with a silylation agent;
- (v) drying the treated gel at a temperature of from about ambient to about 130°C; and, optionally,
- (vi) calcining the gel,

25 at a temperature of less than about 400°C.

7. The process of Claim 6 wherein the silicon in step (i) is in the form of a silicate selected from the group consisting of Si(OR¹²)₄ and SiR¹⁴(OR¹³)₃ where R¹² is a C₁ to C₄ alkyl group, R¹³ is a C₁ to C₈ alkyl group and R¹⁴ is H, C₆H₅ or R¹³, where C₆H₅ is a phenyl group.

30 8. The process of Claim 6 wherein the peroxide-activating metal is selected from the group consisting of silver, cobalt, cerium, manganese, iron, copper, molybdenum, tungsten, vanadium, titanium, chromium and mixtures thereof.

9. The process of Claim 6 wherein the silylating agent is selected from the group consisting of organosilanes, organosilylamines and organosilazanes.

35 10. The process of Claim 9 wherein the silylating agent is selected from the group consisting of chlorotrimethylsilane ((CH₃)₃SiCl), dichlorodimethylsilane ((CH₃)₂SiCl₂), bromochlorodimethylsilane ((CH₃)₂SiBrCl), chlorotriethylsilane ((C₂H₅)₃SiCl), chlorodimethylphenylsilane

- $((\text{CH}_3)_2\text{Si}(\text{C}_6\text{H}_5)\text{Cl})$, 1,2-diethyldisilazane ($\text{C}_2\text{H}_5\text{SiH}_2\text{NHSiH}_2\text{C}_2\text{H}_5$),
 1,1,2,2-tetramethyldisilazane ($(\text{CH}_3)_2\text{SiHNHSiH}(\text{CH}_3)_2$),
 1,1,1,2,2,2-hexamethyldisilazane ($(\text{CH}_3)_3\text{SiNHSi}(\text{CH}_3)_3$),
 1,1,2,2-tetraethyldisilazane ($\text{C}_2\text{H}_5)_2\text{SiHNHSiH}(\text{C}_2\text{H}_5)_2$ and
 1,2-diisopropyldisilazane ($(\text{CH}_3)_2\text{CHSiH}_2\text{NHSiH}_2\text{CH}(\text{CH}_3)_2$).
- 5 11. The process of Claim 9 wherein the silylating agent is selected from the group consisting of the silazanes and N,O-bis(trimethylsilyl)trifluoroacetamide ($\text{CF}_3\text{C}(\text{OSi}(\text{CH}_3)_3)=\text{NSi}(\text{CH}_3)_3$).
12. The process of Claim 6 wherein the water is removed in step ii by
- 10 either a protic solvent or an aprotic solvent.
13. The process of Claim 12 wherein the protic solvent is alcohol.
14. The process of Claim 12 wherein the aprotic solvent is selected from the group consisting of acetone and tetrafuran.
- 15 15. A catalyst composition comprising silica and an oxide of at least one peroxide-activating metal characterized by:
- (i) having a silicon to peroxide-activating atomic ratio of less than 10,000 to 1;
- (ii) being x-ray amorphous;
- (iii) possessing a Si-C infrared band; and
- 20 (iv) having a surface area greater than $500 \text{ m}^2/\text{g}$, a pore volume greater than 0.5 mL/g and an average pore diameter of greater than 4 nm.
16. The process of Claim 15 wherein the peroxide-activating metal is selected from the group consisting of silver, cobalt, cerium, manganese, iron, copper, molybdenum, tungsten, vanadium, titanium, chromium and mixtures thereof.
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